CROSS REFERENCES TO RELATED APPLICATIONS

001 Adolph Mondry – System and method for automatically maintaining a blood oxygenation level. P.N. 5,682,877, November 4, 1997 – herein referred to as 877. The flow charts of that method are similar to those of this method.

002 Adolph Mondry – Method for supplying variable voltage to an electric circuit. P. N. application number 10/739,207. Filing date 12-19-2003. The flow charts of that method are identical to those of this method with different parameters.

003 Lawrence E Bolo et al – Combustion in a multiburner furnace with selective oxygen flow. P.N. application Kind Code A1 20030091948, May 15, 2003. Describes multiburner furnace technology.

004 Ahrmad Al-Halbouni – Method and apparatus for providing low level N sub ox and CO combustion. PN 6,419,480 B2, July 16, 2002. Describes multiburner furnace specification without

automatic feedback as is seen in the present method. It does not determine a circulation time delay.

FEDERALLY SPONSORED RESEARCH GRANTS

004 There are no Federally sponsored research grants available to those involved in the research and development of this method.

BACKGROUND OF THIS INVENTION

005Multiburner Furnaces provide heat and energy. With recent improvements in furnace design the ratio of combustants to oxidants yield lower levels of flue carbon monoxide (CO) in a less fuel rich burn producing less ash and greater efficiency; less flue nitrogen monoxide (NO) in a fuel lean burn, producing less pollution; and, flue temperature balancing decreasing CO and increasing NO. Day to day use may undo these improvements at a cost. It is desirable to have a method available, which automatically controls and prolongs these improvements.

BRIEF SUMMARY OF THE INVENTION

006 It is an object of the present method to control CO, NO, or temperature as byproducts or contaminentsin the flue of a multiburner furnace by delivering appropriate oxidants to the combustants at the burners of a multiburner furnace to increase efficiency and decrease pollution. It is a further object of this invention to provide a method which will prolong all improvements.

007 In carrying out the above objects and other stated objects and features of the present invention a method is provided for maintaining a desired CO concentration, NO concentration, or temperature range (referred to as flue parameters) at the flue of a multiburner furnace and includes delivering initially the largest oxidant (oxygen or air) (delete dose) flow rate to the combustant/oxidants at the burners of a multiburner furnace of any design producing oxidant doses, as tracings of the logarithmic function y=log to the base a of x; or y=1/x; or y= a constant, from one of a plurality of oxidant doses between the smallest and largest oxidant dose. The method includes delivering continuously the largest oxidant (delete dose) flow rate while repeatedly sequencing through

the plurality of sequential flue parameter concentrations (delete doses) at the flue beginning with the smallest flue parameter (delete dose) concentration and proceeding to an adjacent flue parameter (delete dose) concentration in a sequence after a predetermined time interval has elapsed. The largest oxidant (delete dosage) flow rate is delivered continuously until the flue parameter (delete level) concentration attains the desirable range, at which point a corresponding oxidant flow rate (delete dose) is selected from the plurality of sequential oxidant (delete doses) flow rates. The method also includes delivering continuously the selected oxidant (delete dose) flow rate so as to maintain the desired flue parameter concentration range.

008 In the preferred embodiment the method employs CO as the sole flue parameter. Other flue parameters may be employed as well.

009 The advantages of the method are minimal needs for furnace shut downs, less pollution, more efficiency, and a reduction in the cost of running and maintaining a multiburner furnace.

010 The above objects, features, and other advantages will be readily appreciated by one of ordinary skill in the art from the following detailed description of the best mode for carrying out the

method, when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

011 Fig. **1/6** demonstrates a perspective view of the first embodiment of the present method.

012 Fig. **2/6** is a graphical demonstration of the flow charts of the present method.

013 Fig. **3/3-5/6** are flow charts dealing with the oxidant (delete dosage) flow rate and dosage and the CO concentration level strategy of the present method.

014 Fig. **6/6** is a flow chart for relating parameters in the present method.

DETAILED DESCRIPTION OF THE INVENTION

015 Referring now to Fig. **1/6**, a first embodiment of the present method is (delete are) shown. This embodiment indicated by reference number **1** in Fig. **1/6** as a method of automatic multiburner furnace function is the best mode in implementing this method. Figure **1/6** includes **2,** multiburners; **3,** combustants (solid, liquid, or gas): **4,** oxidants (oxygen or air); **5,** a furnace flue; **6,** flue gases; **7,** a flue parameter sensor in Vol% or degree Centigrade; **8,** a band pass filter, which is unique for this method; **9,** the ECU, which is unique for this method; **10,** a variably opening solenoid valve, which is unique for this method; and, **11,** the oxidant entrance.

016 In response to flue parameter sensor **7** data, oxidant flow rates at the inlets (delete "s") **11** are controlled by an ECU **9** controlled variably opening solenoid valve **10** with Coulomb controlling circuits, as was taught in 877 and United States P. N. 5,008,773. It enhances or restricts combustion at the burners **2**.

017 Referring now to Fig. **2/6**, the method of device function is demonstrated graphically. The flue parameters (delete the terminal "s") concentration is (delete are) placed on the ordinate and time

(delete or) and oxidant flow rate (delete dosage) are placed on the abscissa of a Cartesian plane. Maximum or minimum oxidant dosage (defined later) and dose selection occur at tr on the abscissa, the significance of which will be presented later. Tracings of (delete and) calculated logarithmic functions and their reflections and horizontal lines are used in the preferred embodiment as oxidant dosages, but any measured and estimated transcendental function with an inverse may be used.

018 Referring again to Fig. **1/6**, as will be seen, conditions on CO – the preferred flue parameter - control oxidant flow rate **11** to the burners and thus CO concentrations in the flue. The ECU calculates the tracings of all functions.

019 Referring now to Fig. **2/6**, the illustrated method of oxidant flow rate (delete dosage) and CO concentration and oxidant dose (delete range) selection starts with the administration of (delete an extreme) the largest reactive oxidant gas flow rate – herein referred to as the selector dose of the oxidant gas flow rate which produces the maximum (delete or minimum) oxidant dosage – as in curve A (delete or B). Curve A is represented by y=log to the base a of x,

where base a is the smallest in the system. Curve A is labeled MAXR. Curve A activates at x=0.

020 Line CG is the desired CO concentration level – herein referred to as the selection parameter, which is a range in the actual device. At the intersection of line CG and curve A (or B) (call it X), line D points to point E on the abscissa as the selected oxidant flow rate (delete dose). This is determined by graphical means and, as will be seen, the flow charts. Curve B is the minimum oxidant dosage. Which curve is used depends on the initial proximity of any point in the Cartesian plane to Curve A or B. At the intersection of the above curves immediately prior derivatives with respect to time of Curve A and B determine which curve is used. This is true if Curve B is traced as it is as y=1/x. Curve B is labeled MINR. It activates at x=0. The virtual oxidant dosage in Vol % is curve F, which activates at point E, the selected oxidant flow rate, and is boosted by curves A, B, H – an overshoot of curve A – and curve I – a deactivation of curve H – to produce line G, which is the selected CO concentration level (delete ",") and is also an oxidant dosage, and is represented by y=log to the base b of tr, where tr is the t value of the flattening out of the logarithm y=log to the base b

of t (curve F) at tr seconds by line G. Curve F has a similar tracing to curve A, but its base is larger. Line G is completely determined by the intersection (X) described above and in the flow charts, as will be seen. Curve F and line G start in the x coordinate system at x=tR and in the t coordinate system at t=0, when curve A or B deactivates. Curve F and line G deactivate when curve A or B activates. Curve J is the virtual curve of curves A and H. K marks the Circulation time. It marks the time from the initial maximum oxidant gas flow rate to the first recording of any change in the CO concentration (delete dosage). Its accuracy is essential for proper flow chart function with respect to time. Its calculation and that of tr will be demonstrated. The oxidant flow rate (delete dose) and CO concentration are circulation time dependent.

021 Before describing the flow charts it is useful to explain the terminology employed. The most recent base state keeps the CO concentration in its desirable range. The oxidant flow rate and CO concentration level are measured in all states. The oxidant dosage is calculated by the ECU in all states. The washout state washes out overshoots. CO concentrations are functions of oxidant flow rates and conversely.

022 Referring now to Fig. **3/6-5/6**, flow charts are shown, which illustrate the method for the proper selection of oxidant flow rates and CO concentrations and oxidant doses.

023 Referring to Fig. **3/6,** Step **400** determines various system parameters, which may be predetermined and stored in memory, calculated by an ECU (such as ECU **9** in Fig. **1/6**) or entered by a system operator. The system parameters include the following:

Dosage=the tracing in the Cartesian plane of the logarithmic and other functions of flue parameter concentration as a function of oxidant flow rates.

MIN R=minimum dosage of (delete oxidant flow rate) CO concentration as a function of oxidant flow rates given for each range.

MAX R=maximum dosage of (delete oxidant flow rate) CO concentration as a function of oxidant flow rates given for each range.

CO concentration=The preferred flue parameter (delete level) concentration in Vol%

dL=low CO concentration level threshold.

dH=high CO concentration level threshold.

TSS=series state delay time.

Tcirc=circulation delay time.

Twash=washout delay time.

tr=desired response time or reaction time – the t value at dose selection.

Range=a flow sheet with a specific number of increment durations.

IR=number of increments per range.

The value of dH and dL are determined by the current operating state.

024 As shown in Figure **3/6** the ECU now passes control to Step **402**, which measures the oxidant flow rate and CO concentration level and calculates oxidant dosage. At Step **404** a maximum oxidant flow rate of the last range is administered, producing a maximum CO concentration. This is represented graphically by curve A of Figure **2/6** and is called the selector dose. (Delete "It represents the extreme maximum oxidant dose.") The possible CO concentration is set for the lowest level of the lowest range.

025 With continuing reference to Figure **3/6** at Step **406** maximum oxidant dosage is maintained while pausing Tcirc seconds, then x is set to 0 seconds. Step **406** is called an adjustment

state. It coordinates the flow charts with respect to time. Initial circulation times may be estimated or measured.

026 Referring once again to Figure **3/6** the ECU passes control to Step **408**, which continues to deliver the maximum oxidant (delete dosage) flow rate to the burners. Step **408** is referred to as a series state -Tss – and is necessary to coordinate the progression through various possible CO concentration levels within a time period determined by tr. The calculation of Tss depends on the current operating state. Some representative calculations are illustrated in Figure **6/6** for a single ranged implementation as discussed in greater detail below.

027 Still referring to Figure **3/6** a test is performed at Steps **409** and **410.** It asks – is the CO concentration greater than dH? – and, is the CO concentration less than dL?, respectively. They split control into three pathways. Negative answers to both conditions direct control to Step **426**, where 1. The (delete current) CO concentration level is set to the possible level, while the oxidant flow rate (delete dose) is selected. 2. A pause for the circulation time of zero takes place. Then, 3. t is set to 0. This represents oxidant (delete dose) flow rate and CO concentration selection.

028 Now referring to Figure **4/6** processing continues with the ECU directing control to Step **428**, which pauses to washout high valued functions from the desired oxidant dose. The state is completed when all involved functions equal a straight horizontal line – the desired CO concentration, which is a range in the actual device. The oxidant dose is pictured as curve A or B in Figure **2/6** as maximum or minimum doses, but all doses in between are possible. Both of the above dosages continue until activation of MIN R or MAX R. Step **430** measures CO concentration levels for the Conditions below. Steps **432** and **433** represent a second test and ask the same questions as the above mentioned first test – Is the CO concentration greater than dH or less than dL, respectively? If either answer yes, control is directed to Steps **431** and **434,** respectively, where a predetermined fraction of tr is either subtracted or added, respectively to tr. This pathway determines tr only if the circulation time is correct. The circulation time is calculated by keeping the last three base state values in memory. When control is directed to or beyond a noncontiguous base state from which control was originally assumed a predetermined amount of time is added to the circulation time. This will correct

abnormally short circulation times. For abnormally long circulation times – if control passes consecutively to two ascending or descending base states, a predetermined amount of time is subtracted from the circulation time.

029 Referring now to Figure **5/6,** if both conditions in the second test answer no, the ECU places control in Step **436**, the base state. Steps **438** and **440** represent the third test and ask the same questions (is [CO] > dH or < dL?) as those of the previous tests with different consequences. They determine the stability of the base state (both conditions answer no if it is stable). If it is unstable, the ECU directs control to either Step **463,** if Step **438** answers yes, or **446,** which 1. Minimizes or maximizes the oxidant flow rate and consequential CO concentration, respectively 2. Pauses for the circulation time, then 3. sets x=0. These levels continue until dose selection. It should be noted that Steps **431, 434,** the yes part of **418,** and the no part of Steps **433** and **440** all yield control to Step **436**, the stable base state. The ECU then directs control from Step **463** to Step **411,** and from Step **446** to Step **412**.

030 Referring again to Figure **3/6**, the ECU directs control from Step **464** (evaluated later), and if Step **414** in Figure **4/6** (the first

condition of fourth test to be elucidated soon) answers no, to Step **408** to maintain the current [CO] for Tss. Control is then directed to Step **409**, which, if along with Step **410** - the first test – the answer is yes to both conditions, control is passed to Steps **411** and **412**, respectively, which decrement and increment the possible CO concentration, respectively, then both pass control to Condition **414**.

031 Referring now to Figure **4/6**, Steps **414** and **418** represent the fourth and final test with different conditions than the other tests. These conditions ask if the present possible CO concentration is the last one available, and if the present range is the last one available, respectively. If Step **414** answers no, control is directed by the ECU to Step **408** in Figure **3/6**, which maintains a current level for Tss. If the condition answers yes, control is directed to Step **418**, which determines if the present range is the last range available. If it answers no, control is directed to Step **464,** in which control enters a new range, sets the (delete "current exit voltage and voltage producing") oxidant dosage to MAX R or MIN R of the new range, pauses for the circulation time, then sets x=0. Control is then directed to Step **408**, which maintains a current [CO] for Tss. If

Step **418** answers yes, the ECU directs control to Step **436**, the base state.

032 Referring now to Figure **6/6** a flow chart is shown illustrating representative calculations of Tss according to the present invention. One of these calculations or an analogous calculation is performed for each series state of Figure **3/6-5/6**, such as illustrated at Steps **408, 411,** and **412**.

033 Returning to Figure **6/6** at Step **480** a test is performed to determine if the system has reached a base state. If not, the series state delay is estimated as: Tss=tr/IR. If the result is true, the process continues with Step **484**, where a test is performed to determine whether (delete v2) the flue parameter concentration is<dL. If true, then Step **486** determines whether the most recent base state is a minimum for the current range. If it is true, the series state delay is calculated by Step **488** as Tss=tr/(IR-1). Step **498** then returns control to the series state which initiated the calculation.

034 With continuing reference to Figure **6/6,** if the test at Step **486** is true, then the series state delay is calculated by Step **490** as Tss=tr(MAX R-MIN R)/(IR-1)(MAX R-BASE STATE) before control is released to the series state via Step **498.** If the test

performed at Step **484** is false, then Step **492** performs a test to determine if the most recent base state is the maximum for the current range. If the result of Step **492** is true, then Step **496** calculates the series state delay as Tss=tr/(IR-1). Control is then returned to the appropriate series state via Step **498.** If the result of the test at Step **492** is false, then the series state delay is calculated by Step **494** as Tss=tr(MAX R-MIN R)/(IR-1)(BASE STATE-MIN R). Step **498** then returns control to the appropriate series state. Figure **6/6** applies to a single range. One of ordinary skill in the art should appreciate that the calculations may be modified to accommodate a number of possible ranges.

035 It should be apparent to any one skilled in the art that the flow charts provide a method for device function.